ESTCP
Cost and Performance Report

(WP-200301)

Low VOC Barrier Coating for Industrial Maintenance

September 2012

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2012**	2. REPORT TYPE	3. DATES COVERED **00-00-2012 to 00-00-2012**
4. TITLE AND SUBTITLE **Low VOC Barrier Coating for Industrial Maintenance**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Environmental Security Technology Certification Program (ESTCP),4800 Mark Center Drive, Suite 17D08,Alexandria,VA,22350-3605**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**44**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AIM	Architectural and Industrial Maintenance
AQMD	Air Quality Management District
AST	aboveground storage tank
ASTM	ASTM International
CNO	Chief of Naval Operations
CPUA	cost per unit area
DESC	Defense Energy Support Center
DFT	dry film thickness
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DPS	Detailed Performance Standard
EICO	Engineering Innovative Criteria Office
ESTCP	Environmental Security Technology Certification Program
HAP	Hazardous Air Pollutant
HW	hazardous waste
LVBC	low VOC barrier coating
MEK	methyl ethyl ketone
MIL-DTL	Military Detail (Standard)
MIL-PRF	Military Performance (Standard)
MPI	Master Painters Institute
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NPC	Net Present Cost
NTPEP	National Transportation Product Evaluation Program
OSHA	Occupational Safety and Health Administration
POC	point of contact
ppm	parts per million
psi	pounds per square inch
PWL	paint with lead
SBIR	Small Business Innovative Research
SCAQMD	Southern California Air Quality Management District

SF	square feet
SSPC	Society for Protective Coatings
SZC	Splash Zone Coating
TCLP	toxicity characteristic leaching procedure
TOC	total ownership cost
TSA	total surface area
VOC	volatile organic compound
UFGS	Unified Facilities Guide Specification
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
ZVT	zero-VOC topcoat

ACKNOWLEDGMENTS

The project was developed and managed by C. David Gaughen for the Environmental Security Technology Certification Program (ESTCP). This report was prepared by Mr. Gaughen, David E. Pendleton, and Daniel A. Zarate, Naval Facilities Engineering Service Center (NFESC).

We wish to acknowledge the invaluable contributions provided by the following organizations involved in the completion of this project:

- NFESC – Port Hueneme, CA
- Polyspec LLC – Houston, TX
- U.S. Army Corps of Engineers Paint Technology Center – Champaign, IL
- Air Force Civil Engineer Center – Tyndall AFB, FL
- Master Painters Institute – Burnaby, Canada
- National Defense Center for Energy and Environment
- ESTCP Office

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EXECUTIVE SUMMARY

OBJECTIVES OF THE DEMONSTRATION

The objectives of this demonstration are to (1) provide a full-scale validation of the low volatile organic compound (VOC) barrier coating (LVBC) for use as an architectural and industrial maintenance (AIM) coating, (2) assist in the transition of a nonaircraft topcoating using the zero-VOC topcoat (ZVT) (MIL-PRF-85285D, Type III, Class W), and (3) enable the transition of this very low VOC AIM coating system directly into the hands of U.S. Department of Defense (DoD) end users who require aboveground storage tank (AST) maintenance painting.

Corrosion of AST steel exterior surfaces is a perennial and costly problem. To protect against corrosion, AST exterior surfaces typically receive a three-coat system consisting of the following:

- A zinc-rich epoxy primer (Military Detail Standard [MIL-DTL]-24441, Formula 159, Type III);
- An epoxy intermediate (MIL-DTL-24441, Formula 152, Type IV); and
- A polyurethane topcoat (Military Performance Standard [MIL-PRF]-85285D, Type II).

These coats are commonly formulated with about 304 grams per liter (g/l) (2.5 pounds per gallon [lbs/gal]), 340 g/l (2.8 lbs/gal) and 340 g/l (2.8 lbs/gal) of VOCs, respectively. Exterior AST maintenance painting is often required at around 8 to 10 years of service. However, the original three-coat system described above is not appropriate for use over aged and weathered coatings. When the original system has been used as an overcoat system, it has contributed to costly premature coating failures. These overcoat failures typically occur as a result of high levels of residual cure stress (curing of the overcoat system) combined with the daily thermal cycling (daily temperature extremes). Therefore, typical maintenance consists of making spot repairs to visibly corroded areas or waiting until the existing coating is fully removed and a reapplication is necessary.

TECHNOLOGY DESCRIPTION

In effect since August 2006, California's South Coast Air Quality Management District requires all AIM coatings to contain no more than 100 g/l of VOCs. A solution to the environmental problem of using a high VOC AIM coating system is to employ a system consisting of LVBC, developed by Small Business Innovative Research (SBIR), for use as both the spot primer and intermediate coat, followed by the ESTCP validated ZVT

The demonstration was conducted in Southern California at the Defense Energy Support Center (DESC), San Pedro, California. Two ASTs, originally coated in 1987 and located on the waterfront, were recoated with the LVBC/ZVT system. One AST was completely recoated on the top and sides for a total of about 10,500 square feet (SF) of exterior surface area. The other AST was coated on the roof only (2850 SF). The demonstration consisted of the following:

- A determination of coating assessment parameters,

- Examination of the selected tank's exterior coating system to ensure it meets overcoat requirements,
- Surface preparation,
- Application of the LVBC followed by the ZVT, and
- Documentation of established coating application parameters.

DEMONSTRATION RESULTS

The resulting demonstration coating was monitored after 1 year of service in accordance with coating assessment parameters. To date there have been no breaks or bubbling of the overcoats. All coats withstood their respective corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, and LVBC/ZVT patch test adhesion testing in an acceptable or better manner. Additional coating assessments after 4 and 8 years of service are required for an adequate assessment of the technology.

Demonstration results have been used to develop a nongovernment product standard: Master Painters Institute (MPI) #213. Results will also be used to develop a new Unified Facilities Guide Specification (UFGS) entitled "Maintenance Painting of Aboveground Storage Tank (AST) Exterior Surfaces." UFGS will be web-displayed at http://www.wbdg.org/ccb/browse_cat.php?c=3. These documents will be available for direct use by Tri-Service activities with ASTs in need of maintenance painting. In addition, results will be posted at the Joint Service Pollution Prevention Library and presented at the Tri-Service Environmental Centers Coordinating Committee meeting, if applicable.

The ZVT technology contains less than 5 g/l of VOC and the resulting cured paint contains no hazardous materials. Furthermore, the ZVT was developed from novel resin chemistry to be applied using conventional or high volume,-low pressure application equipment.

IMPLEMENATION ISSUES

Both the Army and Air Force exclusively employ a Navy-developed UFGS entitled UFGS 09 97 13.27 "Exterior Coating of Steel Structures" for coating the exterior surfaces of either new ASTs or complete removal or reapplication of previously coated ASTs. The Army and Air Force rely heavily on Navy-developed criteria for use in all AST coating applications. A successful AST demonstration and validation of an AIM coating system based on LVBC/ZVT followed by the availability of new UFGS and MPI guidance documents for these products will lay the groundwork for wide acceptance of this technology.

The LVBC system was applied to the exterior of some small tanks at one project site in accordance with a draft UFGS. The cost associated with this application was approximately 80% of what it would have cost to remove and replace the existing system. On the basis of cost alone, it would have been more effective to remove and replace the existing coating system on the tanks; however, adjustments and lessons learned during the initial implementation of the LVBC system had a significant impact on the cost, and these added costs would not be expected in subsequent implementation. The LVBC has value and the end results have been favorably

received by installation personnel. A finalized version of the maintenance UFGS that can be used by all military services is forthcoming.

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1.0 INTRODUCTION

1.1 BACKGROUND

Corrosion of aboveground storage tank (AST) steel exterior surfaces is a perennial and costly problem. To protect against corrosion, AST exterior surfaces typically receive a three-coat system consisting of the following:

- A zinc-rich epoxy primer (Military Detail Standard [MIL-DTL]-24441, Formula 159, Type III);
- An epoxy intermediate (MIL-DTL-24441, Formula 152, Type IV); and
- A polyurethane topcoat (Military Performance Standard [MIL-PRF]-85285D, Type II).

These are commonly formulated with about 304 grams per liter (g/l) (2.5 pounds per gallon [lbs/gal]), 340 g/l (2.8 lbs/gal) and 340 g/l (2.8 lbs/gal) of volatile organic compounds (VOC), respectively. Exterior AST maintenance painting is often required at around 8 to 10 years of service. However, the original three-coat system described above is not appropriate for use over aged and weathered coatings. When the original system has been used as an overcoat system, it has contributed to costly premature coating failures. These overcoat failures typically occur as a result of high levels of residual cure stress (curing of the overcoat system) combined with the daily thermal cycling (daily temperature extremes). Therefore, typical maintenance consists of making spot repairs to visibly corroded areas or waiting until the existing coating if fully removed and a reapplication is necessary.

In effect since August 2006, California's South Coast Air Quality Management District (SCAQMD) requires all architectural and industrial maintenance (AIM) coatings to contain no more than 100 g/l of VOCs. A solution to the environmental problem of using a high VOC AIM coating system is to employ a system consisting of LVBC, for use as both the spot primer and intermediate coat, followed by ZVT. LVBC was developed by Small Business Innovative Research (SBIR) and ZVT has been validated by ESTCP.

According to the Navy's infrastructure database, the Navy owns more than 1572 storage tanks with a total replacement value of $2.98 billion. This volume includes 803 water storage, 68 ship fuel storage, 19 aviation gas storage, 412 diesel fuel storage, and 270 jet engine fuel storage tanks. AST maintenance painting using the LVBC/ZVT system could reduce annual U.S. Department of Defense (DoD) VOC emissions by as much as 22,750 lbs as well as produce annual saving in excess of $1.5M when compared to complete coating removal and reapplication.

1.2 OBJECTIVES OF THE DEMONSTRATION

The objectives of this demonstration are to (1) provide a full-scale validation of the LVBC for use as an AIM coating, (2) assist in the transition of a nonaircraft topcoating using the ZVT (MIL-PRF-85285D, Type III, Class W), and (3) enable the transition of this very low VOC AIM coating system directly into the hands of DoD end users who require AST maintenance painting.

A second objective is to use the demonstration results to develop a nongovernment product standard: Master Painters Institute (MPI) #213. Results will also be used to develop a new Unified Facilities Guide Specification (UFGS) entitled "Maintenance Painting of Aboveground Storage Tank (AST) Exterior Surfaces." UFGS will be web-displayed at http://www.wbdg.org/ccb/browse_cat.php?c=3. These documents will be available for direct use by Tri-Service activities with ASTs in need of maintenance painting. In addition, results will be posted at the Joint Service Pollution Prevention Library and presented at the Tri-Service Environmental Centers Coordinating Committee meeting, if applicable.

1.3 REGULATORY DRIVERS

The project addresses the following requirements:

- Navy 3.1.04.a — Shipboard Paint and Coating Systems
- Air Force Need 805 — Nonchromated, VOC Compliant Corrosion-Protective Coating System
- Air Force Need 944 — Low-VOC Coating Formulations
- Army A (3.2.j/2.1.h) — Sustainable Painting Operations for the Total Army

Local, state, and federal environmental agencies, such as the U.S. Environmental Protection Agency (USEPA) and California's Air Quality Management Districts (AQMD), classify many VOCs as hazardous and restrict their emissions through regulations such as the Clean Air Act, as well as local USEPA and AQMD rules. Chief of Naval Operations (CNO) directives require significant reductions in the amount of hazardous waste generated by the Navy.

The ZVT technology contains less than 5 g/l of VOC and the resulting cured paint contains no hazardous materials thereby satisfying all of the above requirements. Furthermore, the ZVT was developed from novel resin chemistry to be applied using conventional or high volume, low pressure application equipment.

2.0 DEMONSTRATION TECHNOLOGY

2.1 TECHNOLOGY DESCRIPTION

The first liquid polysulfide polymer became commercially available in 1943, 13 years after the Thiokol Corporation developed and marketed a millable gum polysulfide known as the first synthetic rubber commercially made in the United States. Today, there are several liquid polysulfide polymers, each with distinctly different properties, but similar in chemical structure. To a large extent, products made from liquid polysulfide polymers have the same excellent overall solvent resistance properties as the millable gum polysulfides. However, the liquid polysulfides have the advantage of being room temperature vulcanized, meaning they can be cured at ambient temperatures after the addition of an oxygen-donating curing agent (Figure 1).

$$HS(C_2H_4OCH_2OC_2H_4SH)_6C_2\ H_4OCH_20C_2H_4SH$$

Figure 1. Disulfide linkages (Thiol Terminal Groups: -SH).

Liquid polysulfide polymers are classified as high-quality, application-proven products that can be compounded as sealants, adhesives, coating, potting compounds, and flexible molding compositions, as well as used for impregnating leather and other porous materials. Compounds based on these polymers are used in industrial and building construction, insulation, glass, aerospace, electronics, aviation, marine and many other industries.

The manufacturing process for liquid polysulfide polymers follows the general method of chemical preparation whereby an organic dihalide is reacted with sodium polysulfide at elevated temperatures. A controlled amount of a trifunctional organic halide, which serves to introduce cross-linking sites, is co-reacted in the process. These cross-linking sites permit a range of elongation and modulus properties of the cured polymer.

Epoxy resins date back to about 1949. Their many excellent properties include rapid curing at normal temperatures, good adhesion to most surfaces, toughness and chemical resistance to most dilute acids, alkalis and solvents. Early uses included heavy-duty industrial paints and structural adhesives in the aircraft industry.

Today, epoxy resin compounds are widely used in construction, marine, electrical and industrial markets. However, to meet the different physical properties required for these various markets, certain characteristics of the early epoxy systems have been changed. To “flexibilize” an epoxy, a liquid polysulfide polymer is added. The polysulfide improves certain physical properties without adversely affecting the existing performance capabilities of the epoxy resin.

Versatile systems are possible by co-reacting polysulfides with epoxy resins (Figure 2). These systems exhibit the toughness and adhesion of epoxy plus show the improved impact and general chemical resistance of polysulfide.

O   O
/   \   /   \

$$-R-CH-CH_2 + HS-R'-SH + H_2C-CH-R$$

OH   OH
| |

$$-R-CH-CH_2-S-R'-S-CH_2-CH-R$$

Figure 2. Co-reaction of polysulfides with epoxy resins.

Three different epoxy resins can be used with polysulfides:

- Bisphenol A,
- Bisphenol F, and
- Novolac.

Each epoxy resin has its own special attributes as follows:

Bisphenol A – low cost, low viscosity, high epoxide content liquid resin ideal for coatings, adhesives, casting, potting, encapsulation, and wet lay- up applications.

Bisphenol F – more expensive, lower viscosity than A, and improved chemical resistance. It is more resistant to inorganic acids than bisphenol A.

Novolac – high viscosity semisolid to solid resin with multiple functional groups, with increased cross-link density, better physical properties at elevated temperatures, and improved solvent and chemical resistance compared to bisphenol A and F.

The technology demonstrated was developed in response to the SBIR Program's Solicitation 01.1, "N0-027: Sprayable Polysulfide Elastomeric Development" (Ref 1 and 2). Before this work, neither the government nor industry had developed a viable environmentally compliant barrier coating for use in overcoating marginally sound coating systems previously applied to exterior ASTs. The SBIR objective was to develop a reduced VOC, high solids, environmentally compliant, elastomeric, sprayable, polysulfide-based barrier coating. The coating was also to have low residual cure stress, low hygrothermal stress, sustainable flexibility, high corrosion resistance (hydrolytic stability), and resistance to weathering, moderate tensile strength, sound adhesion, and good chemical compatibility when applied over industrial topcoats. Quantitatively, the SBIR coating was to meet or exceed the following requirements:

- $\geq$ 95% volume solids;
- 140% to 450% elongation;
- Hydrolytic stability (pH 3 to pH 13.5, resistant to cathodic protection);

- 200 pounds per square inch (psi) to 400 psi tensile strength;
- 45°F to 95°F application and curing temperature;
- Internally plasticized;
- <70 psi combined residual cure stress and hygrothermal stress throughout service temperatures and humidity;
- < 1.0×10^{-8} cm/sec water permeability;
- 180 psi to 400 psi adhesion to previously applied coatings;
- Chemically compatible with vinyl, urethane, acrylic, epoxy, and alkyd coatings; and
- Topcoatable, sprayable, and environmentally compliant.

Under this SBIR contract, PolySpec L.P. (the contractor), developed a 99% solids, sprayable, high build, low VOC, two-component, proprietary blend of Bis F epoxy and liquid polysulfide, which displayed maximum adhesion to industrial topcoats, good tensile strength, outstanding flexibility, and very good barrier protection. This low VOC formulation is now virtually free of hazardous air pollutants (HAP).

2.2 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

The main advantages of the LVBC/ZVT system are as follows:

- Compliant with current/future AIM coating VOC requirements for USEPA, state, district and regional counties;
- Elimination of environmental fines associated with AIM coating VOC regulations;
- Reduced coating removal collection, treatment, and disposal costs;
- Reduced facility total ownerships costs (TOCs);
- Rapid AST coating maintenance;
- Enhanced AST corrosion control;
- Flexible, corrosion-resistant barrier coating with low residual cure stress; and
- Maximum adhesion to a variety of topcoats.

The main limitations of the LVBC/ZVT system are as follows:

- Requires industry/coating manufacturer certified coating contractor (Society for Protective Coatings [SSPC] QP1 Certified Contractor).
- May require specialized surface preparation/application equipment.
- Conflicting warranties created by separate LVBC and ZVT manufacturers.
- Single LVBC supplier may require sole source or performance based DoD procurement.

- Coating Condition Survey required for quantifying acceptable overcoating risk.

As quoted in a January 2003 Army publication (Ref. 3), “Industry standards for overcoating do not exist,” and trade journal articles, such as “Overcoating Lead-Based Paint on Bridges: An Overview of Different Coating Options” (Ref. 4) continue to provide valuable information detailing AIM Coating but without providing concrete industry guidance. Overcoating paints and materials such as acrylic latex, calcium sulfonated alkyd, epoxy, conventional oil/alkyd, polyurethane, moisture-cured urethanes, waxes, and tapes have been employed for maintenance painting with variable performance and nonuniform environmental compliance.

3.0 PERFORMANCE OBJECTIVES

Table 1 summarizes performance objectives for LVBC/ZVT in terms of primary performance criteria and expected performance metrics.

Performance objectives are further defined and confirmed employing performance criteria, expected performance metric, and performance confirmation methods, as shown in Table 2.

Table 1. Primary performance objectives.

Performance Objective	Data Requirements	Success Criteria	Results
Quantitative	Condition of demonstration site coating system for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, and LVBC/ZVT patch test adhesion.	Meet minimum pre-demonstration coating system criteria as defined in Table 4.	Defense Energy Support Center (DESC) San Pedro (Americas West) meets all site performance requirements.
Quantitative	Enhanced coating service extension using field performance metrics documenting for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, cracking/checking, chalking, biological growth, and dirt pickup.	Anticipated 50% minimum life extension based upon meeting individual field performance criteria as defined in Table 4.	Preliminary results support minimum 50% service life extension.
Qualitative	Predemonstration coating condition survey for substrate condition, primer classified, midcoat classified, **t**opcoat classified, LVBC/ZVT patch test, salt contamination, and presence of lead/chromium.	Meet minimum pre-demonstration coating condition survey as defined in Table 4.	DESC San Pedro (Americas West) meets all site performance requirements.

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4.0 SITE/PLATFORM DESCRIPTION

California SCAQMD's low VOC requirements for all AIM coatings represent the country's most stringent standards. Therefore, 13 DoD sites within California with ASTs in need of maintenance painting were visually assessed for a potential project demonstration.

4.1 TEST PLATFORMS/FACILITIES

The representative DoD site selected is located in Southern California at the DESC, San Pedro. The site is located at the entrance to the Port of Long Beach and is less than 2000 feet from the ocean. The LVBC/ZVT maintenance painting demonstration was performed on the exterior of two 10,500 SF ASTs (846K gallons each) originally coated in 1987 (Figures 3 and 4). DESC personnel, PolySpec L.P., and the DoD technical points of contact (POC) were involved in performing and assisting with the demonstration at the DESC site.

Figure 3. DESC demonstration site, Long Beach, CA.

Figure 4. View from the top of Tank 2001.

DESC San Pedro exterior AST coating operations generally involve initial coating application using guidance similar to UFGS 09 97 13.27 "Exterior Coating of Steel Structures" followed by either allowing the coating system to fail and then completely removing and reapplying in accordance with UFGS 09 97 13.27 or by performing short-term unsuccessful spot maintenance painting. When complete removal and reapplication in accordance with UFGS 09 97 13.27 is compared to maintenance painting employing the LVBC/ZVT, the major cost differences appear to be as follows:

- Labor-intensive complete removal of existing coating;
- Excessive quantities of spent abrasive blast media and paint debris for disposal;
- Full AST containment during surface preparation;
- Complete reapplication of a three-coat system;
- Potential lengthy AST down time; and
- Higher cost per unit area (CPUA) to install.

4.2 PRESENT OPERATIONS

DESC San Pedro (Americas West) manages bulk fuel and additives distribution to 11 western states, including support to DESC-Pacific locations in Alaska, Hawaii, and the Pacific Rim. Operations at San Pedro primarily involve off-loading tanker fuel, pumping fuel to bulk holding AST/underground storage tanks (UST), followed by underground pipe or truck distribution to DoD activities requiring fuel. The site is subjected to moderate marine exposure, heavy industrial pollution such as acidic fog and dew, and significant ultraviolet exposure.

4.3 SITE-RELATED PERMITS AND REGULATIONS

The industrial painting contractors were required to comply with federal, state, and local environmental regulations throughout all aspects of the surface preparation and coating application as further defined in the following sections of the installation contract.

All surface preparation liquid and paint debris waste was contained, collected, stored and analyzed for hazardous material concentrations before appropriate disposal. The following guide specification sections from the demonstration plan installation contract address these issues.

1. Section 01525 “SAFETY AND OCCUPATIONAL HEALTH REQUIREMENTS” and Section 13283N “REMOVAL/CONTROL AND DISPOSAL OF PAINT WITH LEAD” (where applicable) were part of the demonstration contract and forms the demonstration site “Health and Safety Plan.” These sections are currently titled UFGS 01 35 29 “SAFETY AND OCCUPATIONAL HEALTH REQUIREMENTS” and UFGS 02 82 33.13 20 “REMOVAL/CONTROL AND DISPOSAL OF PAINT WITH LEAD.” To ensure additional “Health and Safety Plan” compliance, the industrial painting contractor was certified by the SSPC to the following:
   - SSPC QP-1 “Standard Procedure for Evaluating the Qualifications of Painting Contractors Performing Industrial Surface Preparation and Coating Application in the Field”; and
   - SSPC QP-2 “Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint.”
2. Section 01572 “CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT,”
3. Section 01575N “TEMPORARY ENVIRONMENTAL CONTROLS,”
4. Section 01770N “CLOSEOUT PROCEDURES,”
5. Section 02120A “TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS,” and
6. Section 09 97 13.27 “Exterior Coating of Steel Structures.”

Local and federal environmental permits associated with construction work were required. These permits will likely change over time. At the very least, an installation may require an approved Notice of Intent (e.g., regional waste water discharge), environmental plan and a site-specific safety plan.

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5.0 TEST DESIGN

The format and general content of UFGS 09 97 13.27 "Exterior Coating of Steel Structures" provided the basis for the demonstration setup and startup including requirements for site preparation and utilities for a full-scale demonstration. UFGS 09 97 13.27 was modified as necessary for the full-scale LVBC/ZVT demonstration and subsequently used as the primary installation contract specification for the demonstration work. In addition, the modified UFGS 09 97 13.27 specification included a "Quality Control Plan" as well as a "Health and Safety Plan."

5.1 LABORATORY TESTING

Laboratory testing of the splash zone coatingwas carried out under the American Association of State Highway and Transportation Official's (AASHTO) National Transportation Production Evaluation Program (NTPEP) for "Structural Steel Coating Systems." The program employs AASHTO Standard Practice R 31-02, which consists of the performance criteria as defined in Table 2 "Laboratory Performance Metrics with Confirmation Methods," below.

Table 2. Laboratory performance metrics with confirmation methods.

Performance Criteria	Expected Performance Metric	Performance Confirmation Method
Primary Criteria (quantitative)		
	NTPEP LVBC/ZVT Testing - R 31-02	
Formula		
Color	Property Documented	Fed. Std. 595, ASTM D 2244
VOC	No more than 50 g/l	ASTM D 2369
Total Solids (wt)	Property Documented	ASTM D 2369
Total Solids (volume)	Property Documented	ASTM D 2697
Percent Pigment	Property Documented	ASTM D 2371
Stormer Viscosity	Property Documented	ASTM D 562
Brookfield Viscosity	Property Documented	ASTM D 2196
Pot Life	Property Documented	N/A
Sag Resistance	No less than 7 mils	ASTM D 4400
Theoretical Coverage	Property Documented	N/A
Drying Times	Properties Documented	ASTM D 1640
Mixing Ratio	Property Documented	N/A
Shelf Life	Property Documented	N/A
Infrared Analysis	LVBC Fingerprint	N/A
Heavy Metals	Free of Chromium, Lead, Cadmium	ASTM D 3335, ASTM D 3718
Dry Film Leachable Metals	Free of Arsenic, Mercury, Silver	TCLP/USEPA SW 846
Epoxide Value	Property Documented	ASTM D 1652
Amine Value	Property Documented	ASTM D 2073
Laboratory Performance		
4000 hrs Salt Fog Resistance	Performance Documented	ASTM B 117, ASTM D 1654
336 hrs Cyclic Weathering	Performance Documented	ASTM D 5894
Abrasion Resistance	Values Documented	ASTM D 4060
Adhesion Testing	Performance Documented	ASTM D 4541
30 Day Freeze Thaw	Performance Documented	AASHTO R 31-02
Atmospheric Testing		
2 Years Exposure	Performance Documented	Severe Marine Exposure, Quantitative Panel Evaluation

ASTM = ASTM International TCLP = toxicity characteristic leaching procedure

5.2 FIELD TESTING

A combination of laboratory and field performance data is mandatory given that laboratory testing seldom reflects field performance and field performance rarely duplicates accelerated laboratory weathering. With the successful meeting of the criteria for 1-year field performance (see Table 3), the results were combined with the NTPEP product testing to develop a LVBC/ZVT formula and laboratory performance based standard. As such, NTPEP product testing data did support full-scale field demonstration data and provided additional LVBC/ZVT data for use in baseline comparisons.

Table 3. Field performance metrics with confirmation methods.

Performance Criteria	Expected Performance Metric	Performance Confirmation Method
PRIMARY CRITERIA (Performance Objectives) (Quantitative)		
Predemonstration		
Coating Condition Survey		
Corrosion	No more than 15% corrosion	ASTM D 610 (% of total surface area)
Peeling	No more than 15% peeling	ASTM D 610 (% of total surface area)
Blistering	No more than 15% blistering	ASTM D 610 (% of total surface area)
Tape Adhesion	No less than 2A	ASTM D 3359 (> 3 tests)
Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)
Film Thickness	No more than 20 mils	ASTM D 4138, SSPC PA-2 (> 3 tests)
Substrate Condition	No Visible Underfilm Corrosion	Visual, 10X Microscope
LVBC/ZVT Patch Test	More than 110 psi and > 2A	ASTM D 3359, D 4541 (3 tests)
Demonstration Application		
VOCs Discharged		
LVBC	VOC emissions reduced by 95%	Quantitative comparison to MIL-DTL-24441/31A
ZVT	VOC emissions reduced by 95%	Quantitative comparison to MIL-PRF-85285D, Type II
Total Debris/Waste Generated		
Surface Preparation	Water/debris collection/disposal reduced by 25%	Quantitative Operation Comp.
Painting	Debris collection/disposal reduced by 25%	Quantitative Operation Comp.
1- and 4-Year Field Performance		
Corrosion	No more than 0.1 % corrosion	ASTM D 610 (% of total surface area)
Peeling	No more than 0.1 % peeling	ASTM D 610 (% of total surface area)
Blistering	No more than 0.1 % blistering	ASTM D 610 (% of total surface area)
Tape Adhesion	No less than 3A	ASTM D 3359 (> 3 tests)
Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)
Film Thickness	Report Thickness	ASTM D 4138, SSPC PA-2 (>> 3 tests)
Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661 (% of area)
Chalking	No less than 8	ASTM D 4214 (% of total surface area)
Biological Growth	No less than 8	ASTM D 3274 (% of total surface area)
Dirt Pickup	No less than 8	ASTM D 3274 (% of total surface area)

6.0 PERFORMANCE ASSESSMENT

A predemonstration assessment strongly indicated that the tank surfaces would be excellent candidates for the LVBC/ZVT overcoat demonstration project. The tests were initiated in October 2003.

Observations of corrosion products, peeling, and blistering indicated all were less than established limits of 0.3% on the walls and sides of both AST 2001 and 2003. There was no visible underfilm corrosion. The preexisting coatings on Tanks 2001 and 2003 were sampled on the roof and walls for coating thickness analyses. Averaged results were 5 and 7 mils dry film thickness (DFT) on the sides and roof of Tank 2001, respectively. On Tank 2003, average results were 4 and 5 mils on the sides and roof, respectively. These are well within the 20 mil limit.

Tanks 2001 and 2003 roof surface salt (chlorides) contamination testing (three samples each) showed minimal results (<1.5 parts per million [ppm] and 2.5 ppm, respectively). Water effluent chloride concentration at Tank 2003 was determined to be 70 ppm. These results indicate little concern for salt contamination affecting coating performance.

Original paint samples were collected from both ASTs to determine paint types to ensure compatibility with the planned maintenance overcoat system. The paint samples were analyzed by Fourier Transform Infrared Spectroscopy to determine organic constituents. The analysis showed that both tanks have an alkyd or other ester-based primer and an alkyd top coat. Metals analyses of these samples showed that the preexisting coatings have relatively high chromium content – 76,700 and 70,700 mg/kg in tanks 2001 and 2003, respectively. Lead content was 1200 and 1300 mg/kg, respectively. The chromium is likely from a yellow chromate primer. Lead pigments are common. The preexisting coating on both tanks were apparently from the same system and likely conform to UFGS 09 97 13.27. This makes it compatible with an LVBC/ZVT overcoat.

Test LVBC/ZVT overcoat patches were applied to tanks 2001 and 2003 (Figure 5). After seven days of cure, tape and pull-off adhesion tests were conducted; three each on the roofs and sides of each tank and the test patches. Adhesion test results of overcoat patches as well as existing coatings (Figure 6) were within the limits established in Table 4, i.e., no less than 2A for the tape adhesion tests and no less than 110 psi for the pull tests. One exception was one of three tape tests on the Tank 2003 LVBC/ZVT test patch which was 1A. However, the three pull test results on this patch were all 110 psi or greater.

Figure 5. LVBC/ZVT test patch.

Figure 6. Adhesion pull test on original coating.

Table 4. Predemonstration survey results: performance criteria.

Performance Criteria	Description	Primary or Secondary
Pre-demonstration		
Condition of Demonstration Site Coating System	Must meet minimum predemonstration coating system criteria as defined by ASTM standards and individually presented in Table 3 for the following: – Coating Type – Corrosion – Peeling – Blistering – Tape Adhesion – Pull-Off Adhesion – DFT – LVBC/ZVT Patch Test Adhesion	Primary
Product Testing		
• Formula • Laboratory Performance	PolySpec L.P. testing, under AASHTO's NTPEP program, performed concurrently with the demonstration; results of formula, laboratory performance, and field performance testing correlated to demonstration performance for use in developing specification standards for the LVBC. Individual ASTM standards for the NTPEP testing are presented in Table 3 and include testing for: – Color – VOC – Total Solids (wt) – Total Solids (volume) – Percent Pigment – Stormer Viscosity – Brookfield Viscosity – Pot Life – Sag Resistance – Theoretical Coverage – Drying Times – Mixing Ratio – Shelf Life – Infrared Analysis – Heavy Metals – Dry Film Leachable Metals – Epoxide Value – Amine Value – 4000 hrs Salt Fog Resistance – 336 hrs Cyclic Weathering – Abrasion Resistance – Adhesion Testing – 30-Day Freeze Thaw Stability – 2 Years Atmospheric Exposure	Secondary
Field Performance		
At 1 Year and 4 Years	Must meet minimum field performance criteria as defined by ASTM standards and individually presented in Table 3 for the following: – Corrosion – Peeling – Blistering – Tape Adhesion – Pull-Off Adhesion – Film Thickness – Cracking/Checking – Chalking – Biological Growth – Dirt Pickup	Primary

The demonstration was conducted in accordance with "Data Quality Assurance/Quality Control Plan" for laboratory testing, LVBC/ZVT coating application, and field tests and inspections.

Surfaces were prepared for overcoating by abrasive scrubbing followed by low pressure water cleaning at 3000 to 4000 psi (Figures 7 and 8). This resulted in about 3% to 4% topcoat removal on the roofs but less than 1% on the walls. Water and debris were collected and removed in accordance with contract requirements. A total of about 70 gallons of LVBC/ZVT coating on Tank 2003 sides and roof was applied by an "airless" pressurized system with best results at about 2800 psi (Figure 9). About 25 gallons were applied by squeegees and rollers to the roof of Tank 2001 (Figure 10). The spray system provided better results. Some rework was required, but overall job quality was acceptable. The need for carefully managed automatic mixing of components and water thinning of the ZVT was the primary need for the on-the-job learning of the paint contractors. This was primarily the need for carefully managed automatic mixing of components and water thinning of the ZVT.

Figure 7. Containment plastic over scaffolding on tank 2003.

Figure 8. Surface preparation by water blasting.

Figure 9. Spray application of LVBC barrier coating on tank 2003 roof.

Figure 10. ZVT applied by rollers on tank 2001 roof.

In addition to the reduction of VOC emissions and overall environmental compliance, a successful LVBC/ZVT maintenance painting application was determined after 1 year of field performance. Long-term performance will be assessed after 4 and 8 years of service.

Pull and tape adhesion tests of the new coating, conducted several days after applications, indicated coating adhesion on tank 2001 roof of between 210 and 250 psi and 4A. Tests on tank 2003 roof and sides indicated adhesion between 190 to 230 psi and 5A. These results show good initial adhesion between the overcoat and the preexisting system – a condition vital to long-term performance. The 10 DFT samples collected from the Tank 2003 roof ranged from 9.5 to 20.7 mils while the 50 samples collected from the sides of the tank ranged from 11.0 to 25.6. The 10 roof samples collected from Tank 2001 ranged from 13.2 to 21.8 mils.

VOC reduction was not measured directly but instead calculated based on VOC content of the LVBC/ZVT coating compared with standard coatings applied in accordance with MIL-DTL-24441/31A (for LVBC) and to MIL-PRF-85285D, Type II (for ZVT). These standard coatings contain 304 g/l (2.5 lbs/gal) and 340 g/l (2.8 lbs/gal) of VOCs, respectively. Laboratory analysis of the coating system applied for this demonstration project showed a VOC content of 65.6 g/L for the LVBC primer and 2.6 g/l for the ZVT. Given that approximately 95 gallons of coating were used (half of which was primer, the other half topcoat), the total VOCs lost to the atmosphere was about 26.6 lbs. If a conventional coating was applied, it would take about 140 gallons and the total VOCs lost to the atmosphere would have been about 371 lbs. The difference between the two systems is over 300 lbs per application area equivalent to that of the demonstration project for a VOC reduction of approximately 93%.

A performance criterion measured during the demonstration application was the total debris/waste generated during surface preparation and painting. Low pressure water cleaning was the principal means for surface preparation for this project because the existing coating did not have to be completely removed. About 3050 gallons of wastewater was collected during the surface preparation of the sides and top of Tank 2003. Only 150 gallons of water were used for the roof of Tank 2001. TCLP analysis of the wastewater showed no contamination that would bar routine disposal.

For the standard coating system, the existing coating would have had to be completely removed via abrasive blasting or water-jetting. This process would have resulted in a much greater quantity of paint, abrasive media, and wastewater; this debris could possibly contain chromium and lead.

The waste solvent generated from cleaning operations such as for equipment is not included in the VOC analysis. Most of this type of waste is recovered and sent to a recycler to be recovered or reclaimed and reused. For example, 20 gallons of methyl ethyl ketone (MEK) were used during this operation and 19.5 gallons were recovered as waste.

Table 5 shows the results of coating evaluations conducted 1 year after coating applications. These data clearly show excellent performance after 1 year (Figures 11 and 12). Much longer exposure periods, however, are required to provide an accurate evaluation of the performance characteristics of this system. A 4-year field performance evaluation is planned.

Table 5. One year field test results summary.

Performance Criteria	Expected Performance Metric	Performance Confirmation Method	Actual Results		
			2001 Roof	2003 Roof	2003 Sides
Corrosion	No more than 0.1 %	ASTM D 610 (% of TSA[1])	0.03%	0.03%	0.03%
Peeling	No more than 0.1 %	ASTM D 610 (% of TSA)	0.01%	0.01%	0.01%
Blistering	No more than 0.1 %	ASTM D 610 (% of TSA)	0.01%	0.01%	0.01%
Tape Adhesion	No less than 3A	ASTM D 3359 (> 3 tests)	5A	5A	5A
Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)	290 psi	260 psi	240 psi
Film Thickness	Report Thickness (DFT)	ASTM D 4138, SSPC PA-2 (>3 tests)	12.7 - 24.8	11.5 - 22	13 - 19.6
Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661 (% area)	10	10	10
Chalking	No less than 8	ASTM D 4214 (% of TSA)	8	8	8
Biological Growth	No less than 8	ASTM D 3274 (% of TSA	10	10	10
Dirt Pickup	No less than 8	ASTM D 3274 (% of TSA)	8	10	10

Note 1: TSA = total surface area

Figure 11. Tank 2003 1 year after application of LVBC/ZVT system.

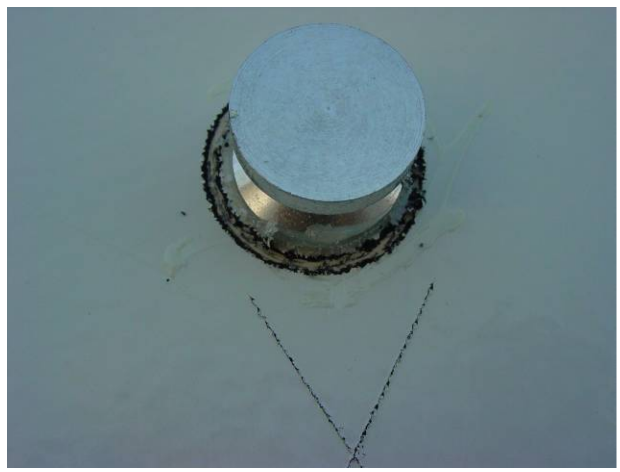

Figure 12. Adhesion testing of the coating after 1 year.

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7.0 COST ASSESSMENT

The objective of this cost assessment is to document the expected costs of implementing an LVBC/ZVT AST maintenance painting option for use on typical AST. By comparing the expected costs of the LVBC/ZVT with typical costs of a conventional coating option, those individuals responsible for deciding on which option is most feasible will have sound economic data to make that decision. The DESC demonstration project, consisting of the coating of Tank 2003 (10,500 SF) and the roof of Tank 2001 (2850 SF), is considered a typical AST coating project for purposes of this economic analysis. In addition to the cost analysis, an estimate of net VOC reduction is provided by comparing VOCs released by conventional coating systems and that of the LVBC/ZVT system for a typical AST coating project. The reader is free to extrapolate any cost savings or VOC reduction for other similar projects. For example, the Navy alone performs coating maintenance on more than 15 ASTs/year with greater than 8000 SF per AST.

7.1 COST MODEL

The painting contractor cost submittal for the LVBC/ZVT demonstration project is included in Table 6. The use of these demonstration costs in the analysis should be tempered by the fact that initial usage of a new approach requires additional training and the development of new techniques or at least the adjustment of conventional techniques. More importantly, the painting contractor, in taking the risk of accepting a nonconventional project, typically submits a higher cost proposal to cover that risk. Thus demonstration cost proposals are typically much higher than full production costs. The estimated costs of a conventional coating system if it was applied to Tank 2003 and the roof of 2001 are also included in Table 6. These costs were determined via phone interview with Premier Coating Systems and represent what the proposal would have been if a conventional system had been specified for the DESC project.

Table 6. Actual costs of the LVBC/ZVT demonstration project compared with estimated costs for a conventional coating.

Description	LVBC/ZVT Contract Cost	Estimated Conventional Coating Cost
Containment	$25,760	$25,000
Coating Materials	$14,700	$20,000
Surface Preparation	$15,375	$30,000
Coating Application	$14,785	$20,000
Disposal	$25,765	$35,000 / $95,000
Total	**$97,385**	**$125,000 / $185,000**

For a conventional system, the existing coating would have to be completely removed and the three-coat system reapplied. The removal of the existing coating (which contains lead) by conventional blasting could create high disposal costs if TCLP testing of the blast debris shows it to be a hazardous waste (HW). Thus, two costs for a conventional coating system are presented: the lower cost if the blast debris is not an HW, the higher cost if it is an HW. All costs in Table 6 include mobilization, labor, equipment rental, supplies, equipment maintenance, utilities, laboratory analyses, and overhead. Not considered are indirect environmental costs such as compliance audits, reporting requirements, document maintenance, and environmental

management plans. These costs would not likely vary significantly between the two coating systems unless the coating removal blast debris is an HW. In that case, the greater indirect environmental costs would be included in the greater disposal cost.

The CPUA of the LVBC/ZVT system for the demonstration project was $7.29/SF. The estimated CPUA for a conventional coating is $9.36/SF or $13.86/SF if the coating removal debris is an HW.

7.2 COST ANALYSIS AND COMPARISON

The cost analysis method employed in this section is net present cost (NPC), which is essentially net present value but considers the fact that there is no cash inflow in maintaining a coating system. In any case, the NPC formula used is as follows:

$$NPC = \sum_{t=1}^{n} [C_t \div (1+r)^t] + C_0$$

Where t = time of cost
n = total time of project – assumed to be 32 years
r = discount rate – assumed to be 5%
C_t = net cost at time t
C_0 = capital outlay at time = 0

For conventional coating systems it is assumed that reapplication must occur every 8 years (8, 16, and 24 years after the initial application) and no spot maintenance painting occurs. The calculated NPC for conventional coating systems based on the costs presented in Table 6 would then be about $500,000 over 32 years ($560,000 if the removed coating debris is an HW for the initial application).

The NPC calculation for the LVBC/ZVT system is not so straightforward. The LVBC/ZVT system is a maintenance coating and can only be applied once over the existing conventional coating. When the maintenance coating fails, the whole coating system must be removed and the conventional coating reapplied. In addition, the time to failure of the LVBC/ZVT maintenance coating has not yet been determined. Therefore, three analyses are provided.

In the first analysis, it is assumed that the maintenance coating lasts 4 years. In this case, application of the LVBC/ZVT maintenance coating is required at years 8 and 20 and the conventional coating system is applied at years 0, 12, and 24 for a total of five applications (three conventional and two maintenance).

In the second analysis, it is assumed that the maintenance coating lasts for 6 years. In this case, the conventional coating is applied at years 0, 14, and 28 and the maintenance system is applied at years 8 and 22. Half of the remaining life of the last conventional system applied remains at year 32 for a total of four and one-half applications (two and one-half conventional and two maintenance).

In the third analysis, it is assumed that the maintenance coating lasts for 8 years. In this case, a conventional coating is applied at years 0, and 16 and the maintenance coating is applied at years 8 and 24 for a total of four applications (two conventional and two maintenance). In these analyses, it is assumed that the coating removal costs by abrasive blasting for the conventional coating plus maintenance coating is the same as that for the conventional coating and that the blast debris is not an HW.

With these assumptions, the NPC for the LVBC/ZVT system when it lasts 4 years is about $570,000; for 6 years it is about $507,000; and for 8 years it is about $445,000.

It can be seen that the breakeven point between use of the LVBC/ZVT maintenance coating approach and that of a conventional system approach is where the LVBC/ZVT system lasts for a little over 6 years. If the LVBC/ZVT maintenance coating system lasts as much as 8 years, then significant savings would result. Given that the longevity of the LVBC/ZVT system is a critical factor in deciding whether it is an economically feasible option, it is important to continue monitoring the performance of the demonstration project coating system for at least 8 years.

The above analysis does not consider the case where the original coating removal debris is an HW. In that event, use of the LVBC/ZVT system would delay and not eliminate the added cost of HW disposal but the NPC would be reduced because of that delay.

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8.0 IMPLEMENTATION ISSUES

8.1 ENVIRONMENTAL CHECKLIST

California's Occupational Safety and Health Administration (OSHA) requires the employer to submit a 24-hour prior written notification before conducting lead-related construction if the lead content is greater than or equal to 0.5% by weight lead. The demonstration site coating systems are classified as paint with lead (PWL). Unless additional analytical data proves otherwise, no prior notification is required. Furthermore, all surface preparation operations have been specified for use with water, which greatly reduces contractor employee exposure to all potential airborne hazards. All surface preparation liquid and paint debris waste is to be contained, collected, stored, and analyzed for hazardous material concentrations before appropriate disposal.

The industrial painting contractor was required to comply with federal, state and local environmental regulations throughout all aspects of the full-scale demonstration as defined in the following sections of the demonstration plan installation contract:

- Section 01525 "Safety and Occupational Health Requirements;"
- Section 01572 "Construction and Demolition Waste Management;"
- Section 01575N "Temporary Environmental Controls;"
- Section 01770N "Closeout Procedures;"
- Section 02120A "Transportation and Disposal of Hazardous Materials;"
- Section 09971 "Exterior Overcoating of AST;" and
- Section 13283N "Removal/Control and Disposal of PWL."

8.2 OTHER REGULATORY ISSUES

A regulatory representative from either SCAQMD of California at Los Angeles or a southern California district representative of the USEPA, or both, may be contacted for participation in the project demonstration evaluations.

8.3 END-USER ISSUES /ORIGINAL EQUIPMENT MANUFACTURERS ISSUES

Concerns, reservations, and decision-making factors affecting LVBC buy-in from DoD end-users will be at a minimum given that technical POCs from the Navy, Army, and Air Force will review and subsequently approve all guidance documents in advance of submission to Naval Facilities Engineering Command's Engineering Innovative Criteria Office (EICO) for guidance inclusion on the Construction Criteria Base website at http://www.ccb.org. The full-scale LVBC demonstration, including the NTPEP testing, will confirm acceptable LVBC performance before drafting new DoD AIM coating guidance.

PolySpec L.P., the LVBC manufacturer, has sales in excess $10 mil/year and large volume production, including international sales and distribution to locations outside the continental USA, is performed daily and is not a concern.

Procurement of the LVBC will be specified in the new UFGS under Section 2, "PRODUCTS" using a combination of performance and formulation properties presented in a table or by reference to a new MPI Detailed Performance Standard (DPS) developed exclusively for the LVBC. Referencing either the new MPI DPS or presenting formulation and performance testing requirements within the new specification is sufficient to enable other coating manufacturer's to compete for LVBC sales and eliminates the requirement of sole source LVBC procurement. As such, LVBC procurement will then become a required contractor's material submittal when preparing a bid for work to perform AIM coating on an AST requiring maintenance painting. Within the new UFGS under Section 3, "EXECUTION" commercial-off-the-shelf surface preparation equipment and LVBC application equipment is commercially available and all equipment will be required to meet performance requirements set by the LVBC manufacturer as well as UFGS specification requirements.

To reiterate, demonstration results will transition into commercial guidance such as a new MPI DPS for the LVBC followed by developing a new UFGS entitled "Maintenance Painting of AST Exterior Surfaces." The DPS and the UFGS will be web-displayed at http://www.paintinfo.com and http://www.ccb.org/ufgs/ufgs.htm, respectively, for direct use by Tri-Service activities with AST in need of maintenance painting. In addition to the above, PolySpec L.P. will continue to produce and market the LVBC to the owner and coating contractor communities, including the Bureau of Reclamation and to state Departments of Transportation (DOT). Other applications of the LVBC may include bridges, offshore structures, structural steel, antenna towers, and concrete structures.

8.4 IMPLEMENTATION STATUS

The LVBC system was applied to the exterior of some small tanks at one project site in accordance with a draft UFGS. The cost was approximately 80% of the cost associated with removing and replacing the existing system. Implementation issues associated with this first on-site application added to the cost.

The most significant issue encountered was that the product had to be heated within a very limited range during application, given that it is a plural component type coating. Due to limitations of heating controls at point of application on existing spray equipment, the product was, at times, applied warmer or cooler than optimum. When this situation occurred, the product had too low of a viscosity when it was too warm, so runs and sags were prevalent or, when too cool, it did not flow well during application.

On the basis of cost alone, it would be better to remove and replace rather than use this new system for maintenance. However, even though there were issues during this first effort that increased cost, adjustments were made that are part of the technology implementation process. The LVBC still has value and the end result is a product introduced into a maintenance specification that can be used by all military services. The draft UFGS will be finalized into one of the first maintenance UFGS's available.

9.0 REFERENCES

1. Anderson, Paul. 2001. *Sprayable Polysulfide Elastomer Development*, SBIR Phase I Contract #N47408-01-P-6339. October 2001.

2. Anderson, Paul and Jason Bell. 2002. *Sprayable Polysulfide Elastomer Development*, SBIR Phase II Contract #N47408-01-P-6339. September 2002.

3. Race, Timothy D., L.D. Stephenson, and Ashok Kumar. 2003. *Decision Tree for Lead-Based Paint Hazard Control and Abatement for Steel Structures.* U.S. Army Corps of Engineers Construction Engineering Research Laboratory. ERDC/CERL TR-03-3. January 2003.

4. O'Donoghue, Mike, Ron Garrett, and V.J. Datta. 2002. *Overcoating Lead-Based Paint on Bridges: An Overview of Different Coating Options.* Materials Performance. September 2002.

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APPENDIX A

POINTS OF CONTACT

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